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APPLICATION FOR UNITED STATES LETTERS PATENT

Title:

CHEMICAL-MECHANICAL POLISHING (CMP) SLURRY AND METHOD OF PLANARIZING COMPUTER MEMORY DISK SURFACES

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CHEMICAL-MECHANICAL POLISHING (CMP) SLURRY AND METHOD OF PLANARIZING COMPUTER MEMORY DISK SURFACES

[0001] This application is a continuation-in-part of application Serial No. 10/677,433 filed October 2, 2003.

TECHNICAL FIELD

[0002] The present invention is directed to a clay-containing abrasive composition and method of planarizing or polishing computer memory disk surfaces. The composition is used as a purified clay-containing aqueous slurry, particularly useful in the manufacture of all types of computer memory disks, e.g., magnetic disks, hard disks, and/or rigid disks for retaining information in electromagnetic form.

[0003] Desk-top computers include one or more memory or rigid disks formed from a substrate that typically is nickel-phosphorus (NiP). A lap-top computer memory disk is formed from a substrate that typically comprises glass, ceramic, or glass-ceramic materials. After planarization, these substrate surfaces are coated with a magnetic material. The memory disk planarization process (polishing) usually consists of two steps: a first polishing step for removing most of the substrate materials on the rough surface of the original substrate, resulting in disks that still have many scratches and other defects on the surface; and then a second, or fine polishing step that eliminates essentially all surface defects and generates a very smooth and planar surface. The clay additives and slurries described herein are useful in both polishing steps.

BACKGROUND

[0004] Compositions for planarizing or polishing the surface of computer memory disks are well known in the art. Polishing slurries typically contain an abrasive material in an aqueous solution and are applied to a memory disk surface by contacting the surface with a polishing pad saturated with the slurry composition. Typical abrasive materials include silicon dioxide, cerium oxide, titanium dioxide, aluminum oxide, zirconium oxide, germania,

magnesia, tin oxide or combinations thereof. U.S. Pat. No. 5,527,423, for example, describes a method for chemically-mechanically polishing a metal layer by contacting the surface with a polishing slurry comprising high purity fine metal oxide particles in an aqueous medium.

[0005] Conventional polishing compositions typically are not entirely satisfactory for planarizing computer memory disk substrates comprising NiP, glass, ceramic or glass-ceramic materials. In particular, polishing slurries can have less than desirable polishing rates, and their use in chemically-mechanically polishing computer memory disk substrate surfaces can result in poor surface quality. Because the performance of a computer memory disk is directly associated with the planarity of its surface, it is crucial to use a polishing composition that has a high polishing efficiency, uniformity, and removal rate and leaves a high quality polish with minimal surface defects.

[0006] There have been many attempts to improve the polishing efficiency and uniformity of conventional polishing agents, while minimizing defects in the polished surface and damage to underlying structures or topography in computer memory disks. For example, U.S. Pat. No. 5,340,370 describes a polishing composition comprising an abrasive, an oxidizing agent, and water, which purportedly yields an improved removal rate and polishing efficiency. Similarly, U.S. Pat. No. 5,622,525 describes a polishing composition comprising colloidal silica having an average particle size of 20-50 nm, a chemical activator, and demineralized water.

[0007] A need remains, however, for compositions and methods that will exhibit desirable planarization efficiency, uniformity, and removal rate during the polishing and planarization of NiP, glass, ceramic, and glass-ceramic material substrates used in the manufacture of computer memory disks, while minimizing defects, such as surface imperfections and damage to underlying structures and topography during polishing and planarization.

[0008] In the parent application, the abrasive composition was prepared very carefully to assure that the clay contained therein had little to no sodium, which would adversely affect the surface being polished. Surprisingly, it has been found in accordance with the compositions disclosed herein, that sodium-containing clays substantially enhance the homogeneity of the abrasive composition to provide uniform planarization of NiP, glass, ceramic and glass/ceramic computer memory disk surfaces.

BRIEF SUMMARY

[0009] Disclosed are compositions and methods for planarizing or polishing a NiP, glass, ceramic or glass-ceramic surface in the manufacture of a computer memory disk. The polishing compositions described herein comprise (a) a liquid carrier, preferably water; (b) an abrasive; (c) purified clay; and optional additives, such as (d) a chemical accelerator or oxidizing agent; and (e) a complexing or coupling agent capable of chemically or ionically complexing with, or coupling to, the NiP, glass, ceramic, and/or glass-ceramic material removed during the polishing process. The complexing or coupling agent carries away the metal, glass, ceramic and/or glass-ceramic particles removed during polishing, to prevent the separated particles from returning to the surface from which they were removed. Also disclosed are methods of planarizing or polishing a NiP, glass, ceramic and/or glass-ceramic surface comprising contacting the surface with the compositions.

[0010] Accordingly, one aspect of the abrasive compositions and methods described herein is to provide a method for planarizing or polishing metal, e.g., NiP, glass, ceramic, and/or glass-ceramic surfaces using sodium-containing clay particles that act as abrasive particles and as a dispersing agent for maintaining a homogeneous abrasive composition.

[0011] Another aspect is to provide a method for planarizing or polishing metal, glass and/or glass-ceramic surfaces using sodium-containing clay particles, in addition to the abrasive material.

[0012] Still another aspect of the compositions and methods described herein is to provide clay abrasive particles, in a water/clay particle slurry having clay abrasive particles dispersed throughout the water and having a particle size such that at least 90% of the clay particles (by number) have a mean particle size in the range of about 0.002μm to about 10μm, preferably about 0.02μm to about 5μm, more preferably such that at least 90% of the particles have a mean particle size of about 0.1μm to about 4μm, to provide a slurry capable of planarizing metal and/or insulator surfaces.

[0013] Another aspect of the compositions and methods described herein is to provide a planarizing composition that comprises an aqueous slurry of clay abrasive particles in an amount of about 0.05 to about 20.0 wt. %, preferably about 0.25 to about 10.0 wt. % of the slurry; an oxidizing agent or accelerator in an amount of 0.01 wt. % to about 20 wt. % of the slurry, preferably about 0.1% to about 5 wt. %, and a chelating agent or complexing agent in an amount of about 0.1 wt. % to about 20 wt. %, preferably about 0.2 wt. % to about 5 wt. %, more preferably about 0.5 to about 2 wt. %, e.g., 1 wt. %.

[0014] The above and other aspects and advantages of the compositions and methods described herein will become more apparent from the following description of the preferred embodiments, taken in conjunction with the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] The polishing compositions comprise (a) a liquid carrier, preferably water; (b) an abrasive; (c) purified, sodium-containing clay; and optional additives, such as (d) a chemical accelerator; and (e) a complexing or coupling agent capable of chemically or ionically complexing with, or coupling to, the metal or insulating material removed from the surface being planarized. The compositions are useful in planarizing or polishing metal, particularly NiP, glass, ceramic, and glass-ceramic surfaces in the manufacture of computer memory

disks. The compositions provide for high polishing efficiency, uniformity, and removal rate, with minimal defects, such as field loss of underlying structures and topography.

[0016] Ranges may be expressed herein as from "about" or "approximately" one particular value and/or to "about" or "approximately" another particular value. When such a range is expressed, another embodiment includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent "about," it will be understood that the particular value forms another embodiment.

[0017] The total solids can be present in any suitable concentration in the slurry compositions described herein. The solids desirably are present in a concentration of at least about 0.25 wt. %, or more (e.g., about 0.25 to about 10 wt. %). Preferably, the total solids concentration is about 0.25 to about 5.0 wt. % of the slurry composition.

[0018] The abrasive particles of the compositions described herein are abrasives known for planarizing a NiP, glass, ceramic, or glass-ceramic surface. Preferably, the abrasive particles are selected from the group consisting of alumina, silica, titania, ceria, zirconia, germaina, magnesia, and combinations thereof.

[0019] The clay is preferably one or more smectite clays, that may be dioctahedral and/or trioctahedral smectite clays. Suitable dioctahedral and trioctahedral smectite clays include the following:

Kaolin type: kaolinite, dickite, nacrite, anauxite, halloysite, endelitte;

Serpentine type: chrysolite, amesite, cronstedite, chamosite, garnierite;

Montmorillonite type: montmorillonite (bentonite), beidellite, nontronite, hectorite, saponite, sauconite;

Vermiculite or chlorite type;

Attapulgite or sepiolite.

[0020] Optionally, an oxidizing component can be incorporated into the polishing composition to promote oxidation of a metal, e.g., NiP, to its corresponding oxide. Preferred

oxidizing components include oxidizing salts, or oxidizing metal complexes, particularly iron salts, such as nitrates, sulfates, potassium ferri-cyanide and the like, aluminum salts, quaternary ammonium salts, phosphonium salts, peroxides, chlorates, perchlorates, permanganates, persulfates and mixtures thereof. Other suitable oxidizers can include, for example, oxidized halides (e.g., chlorates, bromates, iodates, perchlorates, perbromates, periodates, mixtures thereof, and the like). Suitable oxidizers also include, for example, perboric acid, perborates, percarbonates, nitrates, persulfates, peroxides, e.g., hydrogen peroxide, peroxyacids (e.g., peracetic acid, perbenzoic acid, m-chloroperbenzoic acid, salts thereof, mixtures thereof, and the like), permanganates, chromates, cerium compounds, ferricyanides (e.g., potassium ferricynaide), mixtures thereof, and the like. The amount should be sufficient to ensure rapid oxidation of the metal layer while balancing the mechanical and chemical polishing performance of the system, e.g., about 0.1 to about 5.0% by weight based on the total weight of the slurry composition.

[0021] Other possible additives include fillers, fibers, lubricants, wetting agents, pigments, dyes, coupling agents, plasticizers, surfactants, dispersing agents, suspending agents, chelating or complexing agents, catalysts, and the like. The polishing pad matrix material can comprise up to 80 weight percent filler and other optional ingredients. Examples of optional additives include EDTA, citrates, polycarboxylic acids and the like.

[0022] Suitable chelating or complexing agents can include, for example, glycine, carbonyl compounds (e.g., acetylacetonates, and the like), simple carboxylates (e.g., acetates, aryl carboxylates, and the like), carboxylates containing one or more hydroxyl groups (e.g., glycolates, lactates, gluconates, gallic acid and salts thereof, and the like), di-, tri-, and poly-carboxylates (e.g., oxalates, phthalates, citrates, succinates, tartrates, malates, edetates (e.g., disodium EDTA), mixtures thereof, and the like), carboxylates containing one or more sulfonic and/or phosphonic groups, and the like. Suitable chelating or complexing agents

also can include, for example, di-, tri-, or poly-alcohols (e.g., ethylene glycol, procatechol, pyrogallol, tannic acid, and the like) and amine-containing compounds (e.g., amino acids, amino alcohols, di-, tri-, or poly-alcohols (e.g., ethylene glycol, pyrocatechol, pyrogallol, tannic acid, and the like) and amine-containing compounds (e.g., amino acids, amino alcohols, di-, tri-, and poly-amines, and the like). Suitable polishing accelerators also can include, for example, sulfates, halides (i.e., fluorides, chlorides, bromides, and iodides), and the like.

[0023] It will be appreciated that many of the aforementioned compounds can exist in the form of a salt (e.g., a metal salt, an ammonium salt, or the like), an acid, or as a partial salt. For example, citrates include citric acid, as well as mono-, di-, and tri-salts thereof; phthalates include phthalic acid, as well as mono-salts (e.g., potassium hydrogen phthalate) and di-salts thereof; perchlorates include the corresponding acid (e.g., perchloric acid), as well as salts thereof. Furthermore, certain compounds may perform more than one function. For example, some compounds can function both as a chelating and an oxidizing agent (e.g., certain ferric nitrates and the like).

[0024] Preferably, the optional chemical accelerator is a peroxide, such as hydrogen peroxide.

[0025] Any suitable chemical accelerator can be present in the composition. The optional chemical accelerator acts to improve the planarization or polishing of a substrate, for example, as evidenced by an increased rate of substrate removal. If a chemical accelerator is included in the polishing composition, any suitable amount can be used. The chemical accelerator desirably is present in the polishing composition in an amount of about 0.01-about 20 wt. %; preferably about 0.1 wt. % to about 10 wt. %). Preferably, a chemical accelerator is present in the composition in an amount of about 0.25 wt. % to about 5 wt. %.

More preferably, a chemical accelerator is present in the composition in an amount of about 0.25 to about 4 wt. %, particularly about 0.5 to about 2.0 wt. %.

[0026] The pH of the composition is maintained in a range suitable for its intended end-use. The composition desirably has a pH of about 2-12. the preferred pH will depend on the particular chemical accelerator. For example, when the chemical accelerator is ammonium persulfate and NH_3, then the pH preferably is about 9-11. When the chemical accelerator is iron (III) nitrate, then the pH preferably is about 2.5 or less, more preferably about 2. When the chemical accelerator is hydroxylamine nitrate, then the pH preferably is about 2-5.

[0027] The composition can further include one or more other components, such as surfactants, polymeric stabilizers or other surface active dispersing agents, pH adjusters, regulators, or buffers, and the like. Suitable surfactants can include, for example, cationic surfactants, anionic surfactants, nonionic surfactants, amphoteric surfactants, fluorinated surfactants, mixtures thereof, and the like. Suitable polymeric stabilizers or other surface active dispersing agents can include, for example phosphoric acid, organic acids, tin oxides, organic phosphonates, mixtures thereof, and the like. Suitable pH adjusters, regulators, or buffers can include, for example, sodium hydroxide, sodium carbonate, sulfuric acid, hydrochloric acid, nitric acid, phosphoric acid, citric acid, potassium phosphate, mixtures thereof, and the like.

[0028] Any suitable carrier (e.g., solvent) can be used in the composition of the present invention. A carrier is used to facilitate the application of the abrasive purified clay particles onto the surface of a suitable substrate. A preferred carrier is water.

[0029] The method of planarizing or polishing a surface comprises contacting a metal, glass, ceramic or glass-ceramic surface with a composition as described herein. A surface can be treated with the composition by any suitable technique. For example, the composition can be applied to the surface through use of a polishing pad. The rate of removal is

dependent on the rotational speed of the pad the downward force applied to the pad, and the flow rate of the abrasive composition, as well known in the art.

[0030] The compositions are capable of planarizing or polishing a NiP, glass, ceramic or glass-ceramic substrate at a relatively high rate. Furthermore, the abrasive compositions described herein are particularly well-suited for the planarizing or polishing of computer memory disk surfaces, metals. The compositions also can be used in the manufacture of integrated circuits and semiconductors. The compositions described herein exhibit desirable planarization efficiency, uniformity, removal rate, and low defectivity during the polishing and planarization of substrates.

[0031] In accordance with an important feature of the compositions and methods described herein, the polishing composition comprise at least 0.05% by weight, more preferably at least about 0.25% by weight, and up to about 10% by weight, based on the total weight of the abrasive slurry composition, of a purified sodium-containing clay, preferably a sodium montmorillonite or sodium montmorillonite clay.

[0032] The preferred clay material is a sodium smectite clay, such as sodium montmorillonite and/or sodium bentonite and/or sodium hectorite, having sodium as its predominant exchangeable interlayer cation. Sodium smectite clays are preferred since they can be easily exfoliated into predominantly individual platelets, when dispersed in aqueous solutions, for better dispersibility of the abrasive particles in the slurry composition. The clay is first ground to a particle size such that at least 90% of the abrasive particles (by number) have a particle size of about 0.002μm to about 20μm, more preferably about 0.02μm to about 10μm, most preferably about 0.05μm to about 5μm and suspended in water, as a dilute aqueous suspension, e.g., less than about 10% by weight clay, preferably about 5% by weight clay, based on the total weight of clay and water. The dilute suspension then is subjected to high shear conditions, e.g., using a waring blender at 15,000 rpm for 10 to 20 minutes and the

sheared suspension is allowed to settle, e.g., for 24 hours, to settle the grit, quartz, and other non-clay impurities. The sediment is discarded and the purified clay collected in aqueous suspension or divided.